Quality Rice Seed
Production Manual

Research Into Use

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NaCRRI National Crops Resources Research Institute

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Rice Seed Production Manual

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Contents

Acronyms

%	Percent
°C	Degrees centigrade
Av.	Average
CABI	CAB International
cm	Centimetre
DAG	Days after germination
DAP	Diammonium phosphate
DFID	Department for International Development
DRC	Democratic Republic of Congo
DUS	Distinctiveness Uniformity and Stability
EEC	European Economic Community
FS	Foundation Seed
g	gramme
ha	Hectare
IRAT	Institut de Recherches Agronomiques Tropicales
IRRI	International Rice Research Institute
JICA	Japan International Cooperation Agency
K	Potash
K_2O	Potassium oxide
kg	kilogramme
l	Litre
m	Metre
m^2	Metre squared
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
mm	Millimetre

N	Nitrogen
NaCRRI	National Crops Resources Research Institute
NARIC	Namulonge Rice
NARO	National Agriculture Research Organisation
NERICA	New Rice for Africa
NGO	Nongovernmental organization
No.	Number
NP	Namulonge and Pyongyang rice
NPK	Nitrogen Phosphorus and Potash
NRM	National Resistance Movement
NSCS	National Seed Certification Service
P	Phosphorus
P_2O_5	Phosphorus oxide
pH	power of hydrogen (a measure of the acidity or alkalinity of a solution)
RIU	Research Into Use
RYMV	Rice Yellow Mottle Virus
SSP	Single Super Phosphate
t/ha	Tonnes per hectare
USP	Uganda Seed Project
USS	Uganda Seed Scheme
USTA	Uganda Seed Traders Association
WARDA	West African Rice Development Agency (now Africa Rice Centre)
WT	weight

Introduction

Agriculture is the backbone of most economies in Sub-Saharan Africa, and quality seed is the fuel for agricultural development. Rice production, just like any other crop enterprise, requires good quality seed in order for productivity to increase. In Uganda the National Agricultural Research Organization (NARO) serves farmers by developing technologies and desserminating them for improving farmers' livelihoods. In rice research, the Cereals program at National Crops Resources Research Institute (NaCRRI) of NARO is striving to develop and disseminate beneficial rice technologies through partnership with International organizations like CAB International, Japan International Cooperation Agency (JICA), International Rice Research Institute (IRRI) and Africa Rice Centre (Afr*i*caR*i*ce).

Quality Seed production is often one of the areas taken for granted, as farmers realize crop growth even from traditional seed. However, the benefit of seed does not stop at crop growth but goes a long way to grain quality and yield. Through the project, *"Transfer and Dissemination of Emerging agricultural technologies of NERICA: Improving access to quality seed through Private-public partnership"*, the Cereals Program and CABI are focusing on production of quality seed production as a means to improving availability of quality rice seed and increase yields among small holder rice farmers. Besides, phytosanitary measures, an appropriate seed pedigree for various agro-ecological and market situations is a key aspect important in seed production. Farmers need to be aware that poor quality seed, in the first place, gives a poor beginning for the rice crop. The plants often suffer from low seedling vigor, poor growth, non uniform height and maturity, prone to weeds, insects and disease pests, and inability to withstand adverse weather conditions at early stages of growth. Later, the resultant grain quality will be less competitive in the market. This may be witnessed by the significant unit price difference between locally produced rice and imported rice sold in most supermarkets in Uganda. The quality of domestic rice does not match that of imported rice in terms of homogeneity, cleanliness, size and shape. Thus, the starting point in improving the local rice on these aspects is quality rice seed. In addition, if the yield potential of any rice variety is to be realized, good quality seed must be sown. Good quality seed can increase yields by 5-20%. The extent of this increase is directly proportional to the quality of seed that is being sown.

The seed industry in Uganda is now much more a part of a global seed industry than it was in early 2000. There has been an increased effort in the seed industry to make supply and demand for seed measurable. This will help spread the market risk so that there is no over production of seed. In addition, the formation of Uganda Seed Traders Association (USTA) has resulted in production of quality manuals for improvement of internal control systems. The seed regulatory agency, National Seed Certification Agency (NSCA) is working together with USTA in ensuring quality seed is produced and marketed. The major concern however, is lack of technical capacity to produce seed, seed technologists, adequate seed inspectors and weak regulatory laws that need to be addressed to achieve improvements.

The objective of this rice seed production manual is therefore to contribute to improving the capacity to produce quality rice seed which meets the standards of USTA in order to increase the productivity of rice in Uganda. The manual is a quick reference material for extension agents and farmers in the rice seed sector who are already involved in production or are planning to produce certified seed of rice. Normally, cultural operations for conventional crop production are similar to those for seed production but additional operations, such as isolation, roguing to ensure the quality of seeds make a great difference. Such seed quality control operations are conducted to make the seed true to type and to sustain the genetic potential of the intended variety.

Seed Sector in Uganda

The formal seed supply system in Uganda was established in 1968 as a government scheme with support from British Overseas Development Agency that formed the backbone of the seed industry in the country. The national agricultural research program of the Ministry of Agriculture was an integral part of seed industry in variety development, maintenance and production of breeder, foundation and certified seed until late 1990s. The National Agricultural Research System was also transformed into the National Agricultural Research Organization in 1992 in which research opened up to actively encourage the involvement of private sector and other stakeholders in setting research priorities to respond to demand driven and responsive needs of the farmers. Eventually, the seed sector was liberalized in early 2000, that saw the emergence of private seed companies. Ever since, significant changes have occurred in Ugandan seed industry especially with the sale of the last Government interest in seed business. This confirmed Government commitment to enable private sector invest in research and development and take lead in provision of agro-inputs and services to the farming community. This, to many was a good policy for it would bring efficiency because research would be demand driven with clear objectives and targets.

The private seed industry although young and still developing has already proven it's worth and lived to expectation. Some of the successes to its credit are: **1).** Opening up alternative channel through which improved crop varieties can reach the farmers. This is in sharp contrast with a few crop varieties previously marketed by the Government Seed Project; **2).** It spearheaded the sale of agro-inputs other than improved seed i.e. fertilizers, pesticides, small implements and even agronomic packages to farmers through its distribution channels something that had never happened in Uganda; **3).** It has been the force behind the releasing and marketing of crop varieties in the region; and **4).** It initiated the setting up of demonstrations, shows and exhibitions for farmers and other stakeholders to see the new varieties, other agro-inputs and agronomic packages; this in turn has created awareness and demand for them.

The seed industry in Uganda is now much more a part of a global seed industry than it was in early 2000. There has been an increased effort in the seed industry to make supply and demand for seed measurable. This will help spread the market risk so that there is no over production of seed. The seed regulatory agency (National Seed Certification Service - NSCS) is working together with USTA in ensuring quality seed is produced and marketed.

Seed System of Rice in Uganda

Seed class	Activity / Institution responsible	Location	Method / Quantity / ratio
Nucleus Seed = Pre-Basic Seed	Seed developed at NaCRRI or introduced from WARDA / IRRI / any source to Uganda, tested, found suitable and released as variety by NaCRRI / NARO / MAAIF (Variety Release Committee). Nucleus seed of each such variety released by NARO must be maintained by NaCRRI.	NaCRRI, Namulonge	500 single plant-progenies should be maintained by growing single plant progeny-rows. Progeny-bulk to serve as seed source for Breeder Seed production.
Breeder Seed = Basic Seed	Breeder Seed of the varieties must be multiplied only by NaCRRI. A committee jointly with NSCS to inspect the field and ascertain the quality of individual variety.	NaCRRI, Namulonge	Bulked Nucleus Seed used to produce about one ton of Breeder Seed per variety.
Foundation Seed = 1st Generation	Any Private Seed Company, NGO, organization or individual registered with NSCS can produce Foundation Seed (FS). NSCS will carry out field inspection and Laboratory Tests for quality analysis. NSCS also to monitor post-production quality of the seed being sold to farmers.	All over Uganda	Breeder Seed used for producing Foundation Seed in any marketable quantity. Multiplication ratio of 1: 40 for Upland and 1: 70 for lowland varieties.
Certified Seed = 2nd Generation	Any Private Seed Company, NGO or individuals registered with NSCS can produce certified seed. NSCS will carry out field inspection and Laboratory Tests for quality analysis. NSCS also to monitor post-production quality.	All over Uganda	FS, 1st or 2nd Generation Certified Seed used as seeding material to produce sufficient quantity. Multiplication ratio of 1: 40 for Upland and 1: 70 for lowland varieties.
Truthful Seed = Standard Seed	Any one who can produce seed of same quality as Certified Seed	All over Uganda	FS, 1st or 2nd Generation Certified Seed used as seeding material to produce sufficient quantity. Multiplication ratio of 1: 40 for Upland and 1: 70 for lowland varieties.

Rice Seed Production

Traditional and Modern Rice Varieties

In conventional rice breeding, the end product is a pure-line.

- Pure-line is a progeny of a self pollinated homozygous mother plant and breed true to type
- Any traditional rice variety is a pure line. If they were not subjected to selection, there can be inherent genetic variability accumulated within them over a long period of time
- Cross breeding is to bring together desirable traits of different varieties
- Breeder needs 7 to 8 generations to fix the traits to develop a variety. A further 5 to 6 seasons are needed to test its adaptability prior to recommendation
- The modern rice varieties (pure-lines) derived from cross breeding breed true to type
- A rice variety is bred once only. Thereafter it is just multiplied while maintaining purity by removal of off-types / admixtures
- No degeneration or loss in vigor in pure-lines (self pollinated crops) due to inbreeding

Seed Production

Self seed production plays a vital role in subsistence agriculture.

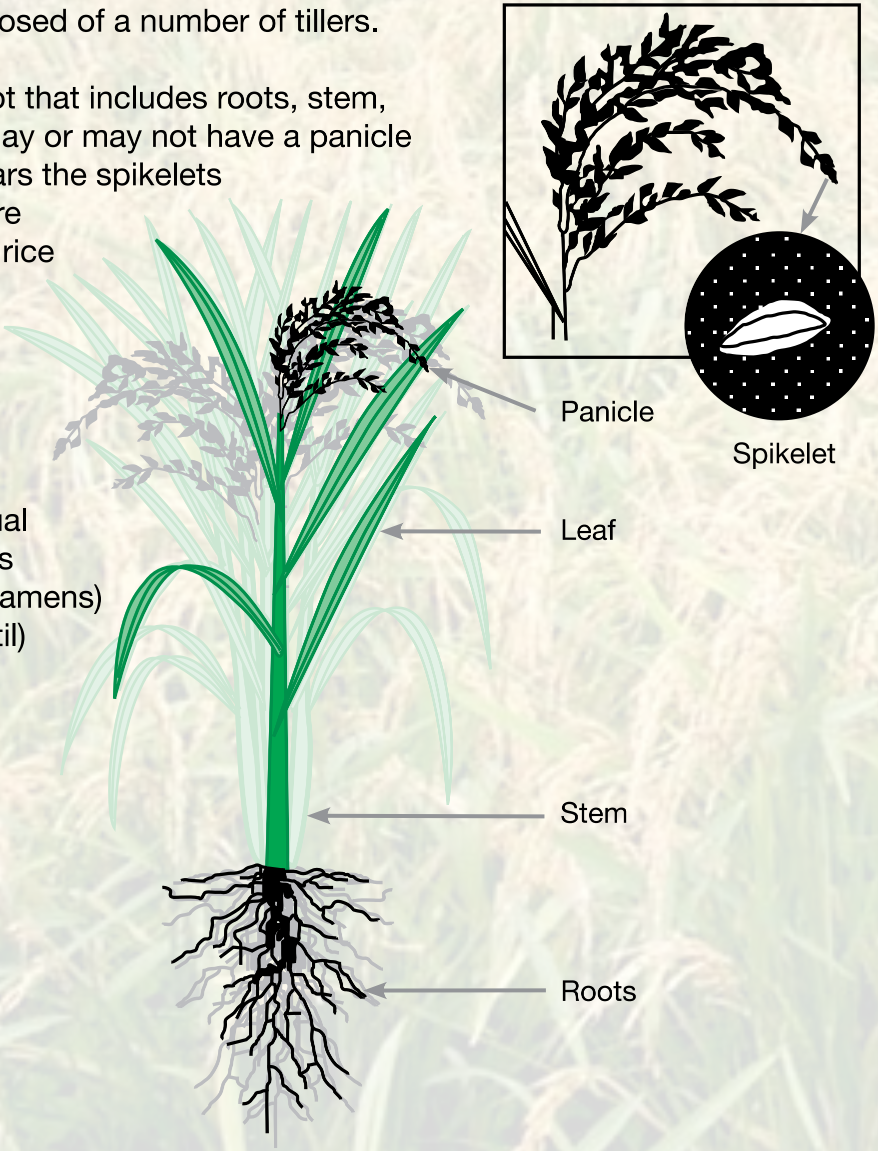
- Rice is a self pollinated crop
- Seed production in self pollinated crops does not demand special plant breeding skills
- Self pollinated crops in nature breed true to type; produces progeny similar to mother plant
- Genetic purity of rice varieties can be maintained by removing the off-types detected in the field
- New rice varieties developed through cross breeding are not different from the traditional types in their breeding behavior

The rice plant

Rice plant is composed of a number of tillers.

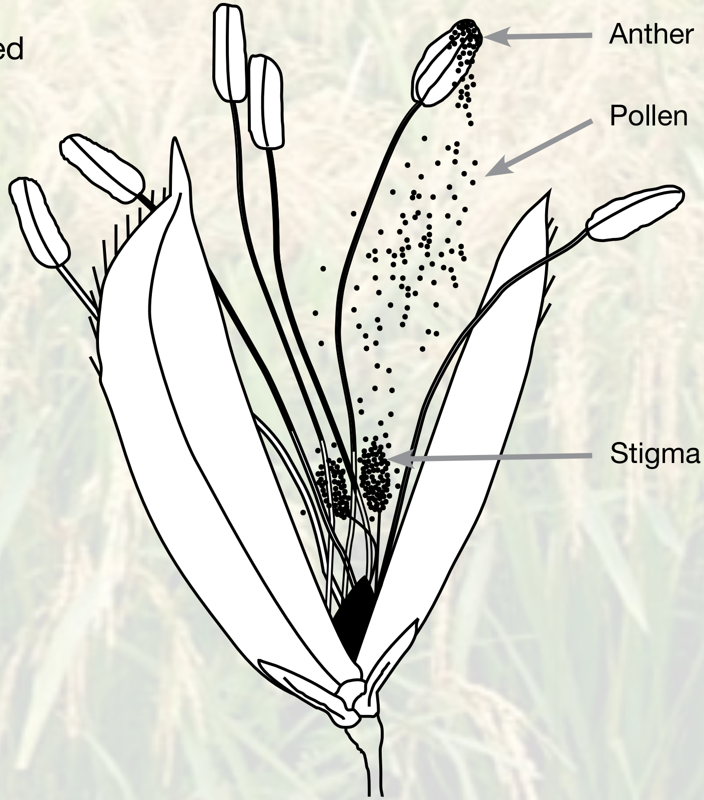
- A tiller is a shoot that includes roots, stem, and leaves. It may or may not have a panicle
- The panicle bears the spikelets
- The spikelets are the parts of the rice plant that form seed

- **Rice Spikelet**
  Rice flower is hermaphrodite and the individual spikelet consists of both male (stamens) and female (pistil) reproductive organs



Natural Breeding Mechanism of Rice Plant

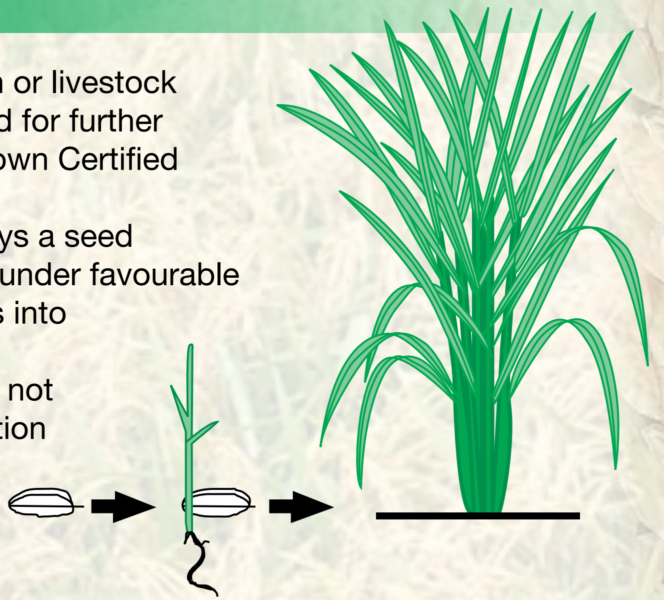
- The process of pollination takes place within the same flower, ensured by a mechanism called cleistogamy
- Cleistogamy - rupture of anthers (male) to shed pollen over stigma (female) of the same flower prior to or simultaneous with the opening of the glumes of spikelets (see figure below). Pollination takes place with the opening of the glumes of the spikelet. The stigma is pollinated by pollen grains shed from anthers in the same spikelet. This process ensures self pollination in rice
- As a consequence, rice plant is almost 100 % self-pollinated and therefore it is considered an inbreeder
- Inbreeders are homozygous and breed to type. Progeny always resembles the mother plant



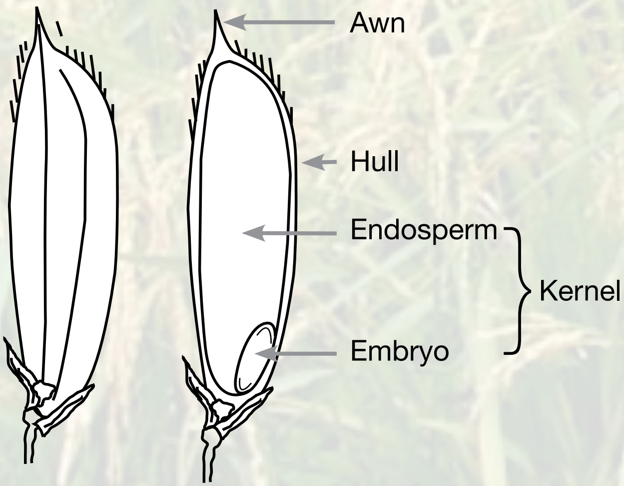
Pollen from the same spikelet

The seed and grain

- Usually grain is produced for human or livestock consumption while seed is produced for further multiplication of the variety from known Certified Seed Sources
- Seed is a grain but grain is not always a seed
- A mature rice grain that germinates under favourable environmental conditions and grows into a normal plant is called a seed
- A mature rice grain that may or may not germinate and is used for consumption is not a seed
- Only seed can be legally sold to farmers to grow a rice crop



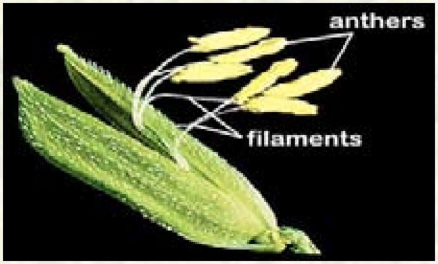
Parts of a rice seed

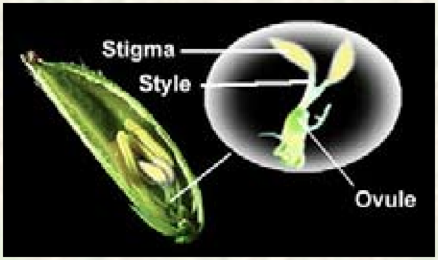


The seed was cut lengthwise

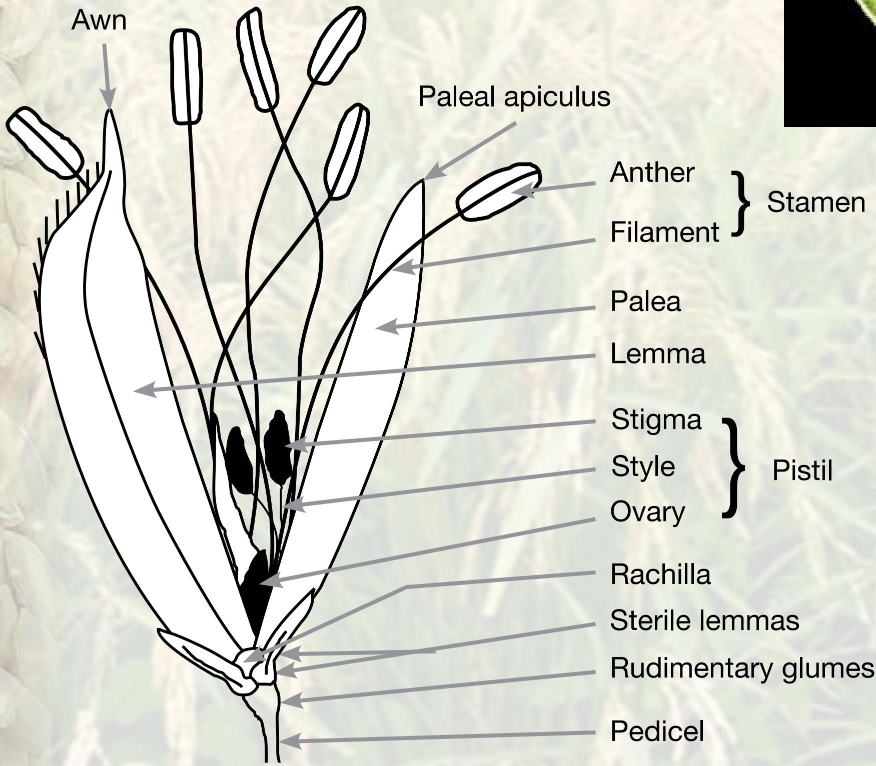
- The embryo or germ gives rise to a seedling, which is composed of the shoot and roots
- The endosperm is a food reserve for the germinating embryo during its early growth. It is made up mostly of starch. It also contains sugars, proteins, and fats
- The hull is the hard cover of the seed.
- Most improved rice cultivars either do not have awns, or the awn is very small

Process of seed formation





- Pollination is the first step in reproduction
- Pollen grains are shed from the anthers and fall onto the feathery stigmas (See figure below)
- Fertilization is the second step in seed formation. The pollen that reaches the stigma germinates and forms a pollen tube that carries the male nuclei inside the ovary for fusion with the egg nuclei
- The complete process from pollination to fertilization takes from 18 to 24 hours



The rice seed

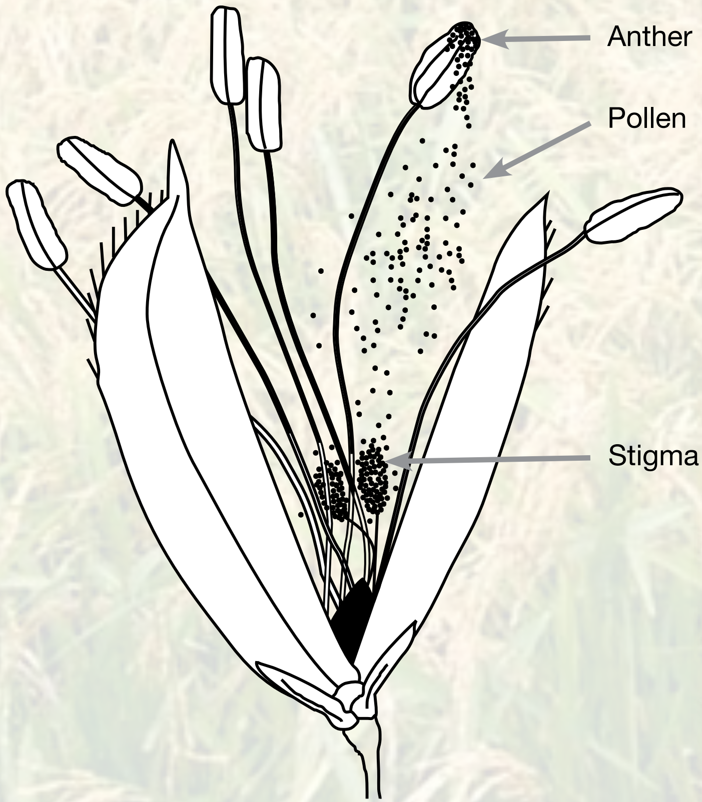
Ordinary rice seed is produced when the egg inside the ovary is fertilized by pollen grains shed from:

1. Anthers borne in the same spikele (cleistogamy)

2. Anthers from other spikelets of the same plant

3. Anthers from the spikelet of another plant of the same variety

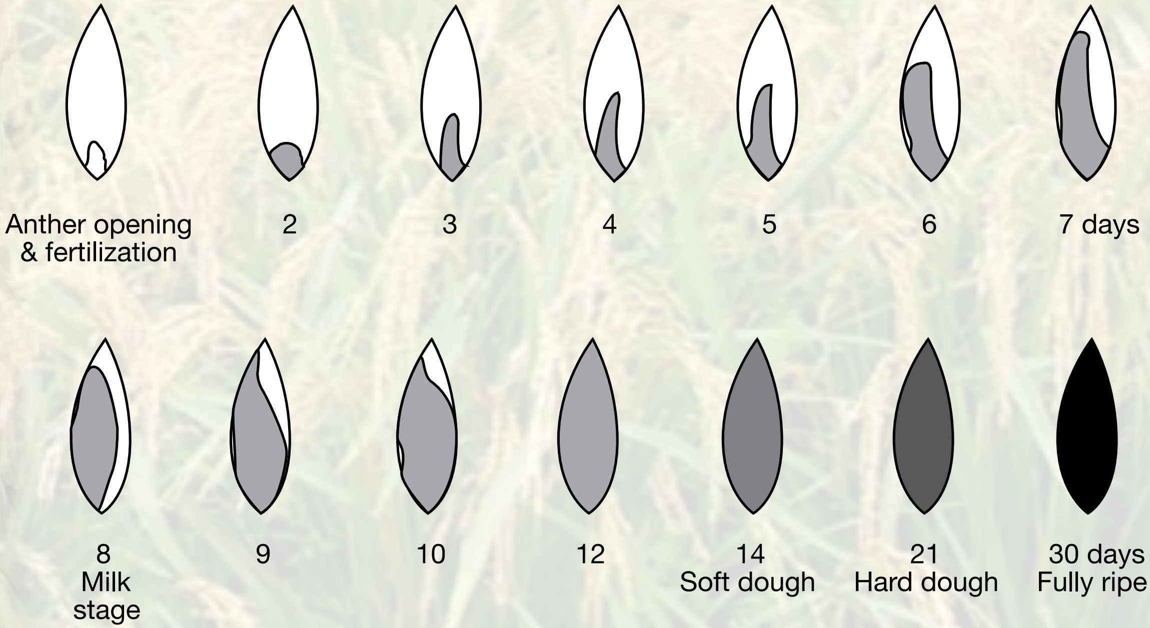
When farmers plant an entire field to a single variety, they are producing inbred seed.



Pollen from the same spikelet

Stages of seed formation

- The fertilized egg cell begins development within 12 hours after fertilization
- The endosperm of the developing seed begins turning milky white 8 days after fertilization
- The embryo develops after 10 days
- The endosperm turns into the soft dough stage at 14 days after fertilization, and the hard dough stage 7 days later
- Within 25-30 days after fertilization, the ovule has matured and fully ripened into a seed



Rice breeding aspects

In conventional rice breeding, the end product of breeding is a pure-line. Pure-line is a progeny of a self pollinated homozygous mother plant and breed true to type. The process of pollination takes place within the same flower, ensured by a mechanism called cleistogamy. Cleistogamy means rupture of anthers (male) to shed pollen over stigma (female) of the same flower prior to or simultaneous with the opening of the glumes of spikelets. As a consequence, rice plant is almost 100% self-pollinated and therefore considered an inbreeder. Inbreeders in this context are homozygous and breed true to type i.e. progeny always resembles the mother plant. Any traditional rice variety is a pure line. However, if these varieties are not subjected to selection, there can be inherent genetic variability accumulated within them over a long period of time.

Cross breeding is to bring together desirable traits of different varieties. After making crosses, breeders need 7 to 8 generations to fix the traits to develop a variety. A further 5 to 6 seasons are needed to test its adaptability prior to recommendation. The modern rice varieties derived from cross breeding also breed true to type. In general, a rice variety is bred once only. Thereafter, it is just multiplied while maintaining purity by removal of off-types / admixtures. Rice is a self pollinated crop (pure-line) and no degeneration or loss in vigor in pure-lines can result due to inbreeding. In addition, seed production in self pollinated crops does not demand special plant breeding skills. Self pollinated crops in nature breed true to type, hence genetic purity of rice varieties can be maintained simply by removing the off-types detected in the field.

Types of seed

There are three types of seeds; breeders' seeds, foundation seeds, and certified seeds. Seed production starts with the breeder in a Research Institute. When new varieties are developed, very small quantities of their seeds are produced by the breeders and made available to organizations and seed companies that have the responsibility to multiply them so that many more farmers can get them to use. The small quantity of seeds that breeders produce are referred to as breeders' seeds. These are given first to potential private seed companies, in the case of Uganda, who use them to produce foundation seeds. The Seed Companies multiply the foundation seeds with the assistance of trained farmers to produce certified seeds. The certified seeds are the seeds sold to farmers by the Seed Companies or private seed growers to produce grain for food and for sale in the market. Some farmers who have been trained to produce certified seeds may also produce foundation seed which is later sold to seed companies on contract basis.

Why use good seeds?

Farmers should always use good seeds for the following reasons:
- Reduced seeding ratio due to higher germination
- Reduce the need for replanting
- Give more uniform plant stand and thus make harvesting easier
- Give more vigorous early plant growth which helps the plant to compete better with weeds and resist insect pests and diseases
- They have early maturity, and are pest/disease/drought tolerant or resistant
- They give higher yields and better grain quality due to less cross contamination with other varieties
- They result in fewer immature seeds leading to higher milling

What are good seeds?

Good seeds are pure (of the chosen variety), full and uniform in size, viable (ensure more than 80% germination) and free from weed seeds, seed-borne diseases, pathogens, live insects, or other matter. Good seeds should have a name which means every seed package should have a label.

Where do farmers get seeds?

The seeds that farmers use in Uganda are secured from:
- Their own saved seeds
- Seed producers within their communities, including neighbours, relatives, and friends
- The open market, including commercial seeds/grain
- Research Institutes (e.g. NARO) and NGOs

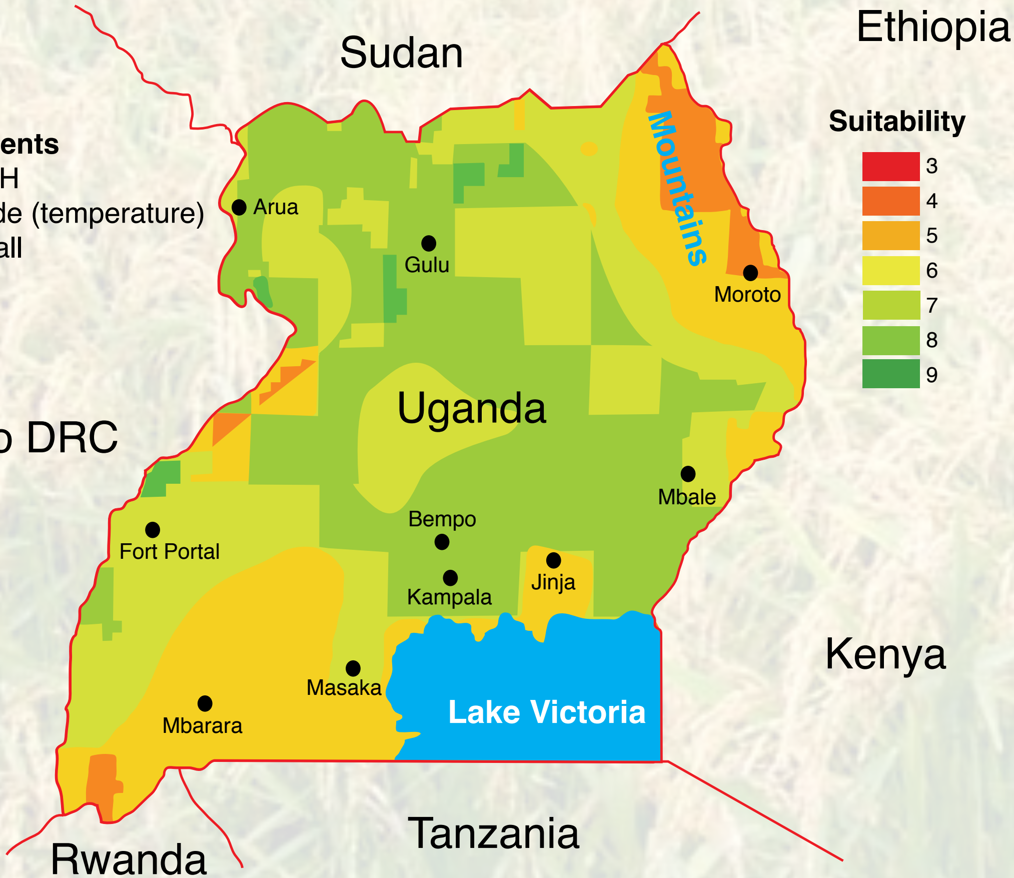
About 95% of the seeds used by farmers are usually from within their community, from neighbors and friends because private companies are yet to vigorously promote improved seeds in the country. The quality of the seeds from these sources is uncertain and they are often a mixture of several varieties because of lack of technical skills. Thus, improving the adoption of improved seeds in Uganda is dependant on building the capability of farmers and community-based groups to produce good seed.

Pre-requisite control practices in seed production:
- Selection of land with required cropping history
- Free from sources of seedborne diseases
- Isolation of seed crop from possible contaminants of foreign pollen of some species
- Roguing off-types and volunteer plants

Suitability map for NERICA cultivation in Uganda

Components

- Soil pH
- Altitude (temperature)
- Rainfall



Growing Certified Rice Seed – Upland Rice

Upland rice refers to rice varieties that can complete their production cycle while depending on rainfall or partly rainfall is supplemented with some ground water supply. They are less adapted to high water levels than the lowland rice.

Upland rice varieties in Uganda

Earlier, upland varieties grown in the country before 1970 were Bungalla and Sindano. Bungalla has been abandoned due to its high susceptibility to the fungal disease, Rice Blast. Sindano is still grown in some parts of the country. In the 1990s the following upland varieties were availed; IRAT 112, NP-2, and NP-3. But up to 2002, the popular upland varieties grown were Sindano grown in the Northern and Eastern parts of the Country; and IRAT 112 popularly called Abilony. Recently, five Superior upland varieties have been released and their attributes are detailed below. While the earlier varieties yielded less than 1.5 t/ha under optimum management, the new recommended varieties yield more than 3t/ha.

Varieties and their sowing requirements

Varieties	Maturity period (days)	Date of sowing	Seed rate (kg/ha)	Plant spacing (cm)	Depth of sowing (cm)
NARIC 1	115	**1st season:** Late Feb to mid March **2nd season:** Late July to mid August	55-60 (Dibbling), 70-75 (drill seeding)	Dibbling: 30 x 15 or 20 x 20 Drill seeding: 30 cm between rows	3-4
NARIC 2	120	ll	ll	ll	3-5
NERICA 1	110-115	ll	ll	ll	3-4
NERICA 4	120	ll	ll	ll	3-4
NERICA 10	110	ll	ll	ll	3-4
SUPERICA 1	120	ll	ll	ll	3-5

Choice of land

For seed production, choose fertile land with good drainage and good water retention capacity (contains some clay and/or organic matter, i.e. loamy soil) that is exposed to the sun and not prone to erosion. If you have to grow rice for more than one consecutive years on the same piece of land without crop rotation, seek the advice of the Soil Survey and Testing Service of Makerere University or any other reputable soil-testing unit. Hydromorphic areas are preferable for seed production to minimize risks of total crop failure. These are low lying areas that store substantial amount of water for greater part of the growing season in the soil.

Land preparation

Proper land preparation is necessary for rice seed production to minimize competition with weeds. A poorly prepared field, under direct seeded conditions, will make the crop to emerge differentially leading to a wider spread of grain moisture at harvest. This can lead to damaged grain if the crop is mechanically threshed.

Prepare the seed bed before the onset of the rains depending on the seasons in the location. For newly cleared areas, cut down big trees before the start of rainy season, preferably from December to February, and remove all stumps, roots and trees before ploughing. Plough once and harrow twice to make a good tilth if the land is flat. Plough once and harrow once if the land is sloppy. For fields that are prone to erosion, divide the land into plots of 50x50 m or 50x100 m and construct bunds, depending on the slope, to accumulate rain water and also to allow good drainage. The surface of the field should be made as leveled as possible. Cut areas in the field may mature sooner than fill areas leading to large differences in grain moisture content which consequently leads to grain/seed fissuring. A well leveled field ensures uniform water depth throughout the season and contributes to uniform ripening across the field and

consequently, more consistent moisture content in the grain between locations. If the rainy season is short, the ploughing is done at the end of the previous season. Deep ploughing (10-25 cm) is preferred for proper weed control. Apply basal fertilizer before final harrowing (see more on fertilizer application for types and rates to use).

In areas where the soils are more fragile and prone to erosion, minimum or zero tillage may be practiced. Where zero tillage is to be adopted, the field should be sprayed with glyphosate (herbicide) at the rate of 4 L/ha to kill emerged weeds. About 10 days after spraying glyphosate, slash or mow the dead weeds.

In summary, a well prepared/leveled field reduces the work in crop establishment and care, and increases yields. Leveled land also improves water coverage that:

- Reduces the amount of water required for land preparation
- Improves crop establishment and care
- Decreases the time to complete tasks
- Results in better crop stands
- Reduces weed problems
- Results in uniform crop maturity

A well leveled rice field leads to uniform maturity

A well leveled rice field ready for planting

Seed preparation

After deciding on the rice variety to use, select plump viable seeds that will grow vigorously.

Key aspects that a seed grower needs to do in seed preparation include:

1. **Breaking seed dormancy**
   - Dry the seeds in the sun for 1 or 2 days before planting
   - Rice seeds lose viability considerably after 11 months of proper storage Preferably plant within 1 year
   - Both the NERICA variety (NERICA 4) and other upland rice varieties have short dormancy period 4-7 days
   - Best seed for planting should be that harvested in a particular season and planted in the corresponding season of the following year
   - If rice is harvested and it is to be planted immediately the following season, dry thoroughly before planting

2. **Seed cleaning**
   - Seeds should be cleaned by winnowing to remove the chaff. The remaining poorly filled grains should be removed by the use of water (soak the seeds and skim-off the floating seeds). The seeds that sink are the best for planting

3. **Germination test**
   - A germination test is often the only test a farmer can conduct on his/her seed before planting. Monitoring the time taken to germinate will also give an indication of vigor. This procedure is very easy, inexpensive and portable
   - To obtain a random sample for testing, it is always best to take samples from different parts of the bag or container. If the grain to be tested is from a seed lot that contains more than one bag, samples must be taken from several bags. A good rule of thumb for determining how many bags to sample is to take samples from a number of bags that represents the square root of the lot size. For example if the lot contains nine bags, then sample at least three

bags. If the lot contains 100 bags, then sample at least 10 bags

To conduct this test you will need to follow the following procedure

1. Place water absorbent material inside waterproof tray
2. Take random sample from each seed lot and mix in a container
3. Take at least three seed samples from the mixed grain
4. Count out 100 seeds from each sample and place on absorbent paper inside the tray
5. Carefully saturate absorbent material with clean water
6. Each day check that absorbent materials remain moist and record number of germinated seeds. Do this for 10 days
7. Compute germination test for five days and ten days
8. Rate of germination is an indicator of vigor. Rapid seed germination increases the chance that seed will establish in the field

Calculating germination rate. Germination rate is the average number of seeds that germinate over the five-day and 10-day time period.

$$\text{Germination (\%)} = \frac{\textit{Number of seeds germinated}}{\textit{Number of seeds put on the tray}} \times 100$$

Example: If 86 seeds germinated in a tray of 100 seeds
Germination (%) = 86/100*100 = 86%

A seed grower should know what seed viability means

What is seed viability? The viability of the seed is a measure of how many seeds are alive and could develop into plants which will reproduce themselves, given the appropriate conditions.

Why do we test seed viability? It is important to know that the seeds that are stored will grow to produce plants. Therefore they must have a high viability at the start, during and at the end of storage.

When should viability be determined? Viability will need to be determined at the start of storage and at regular intervals during storage to predict the correct time for regeneration of the variety. The viability test takes from a few days to weeks or even months to give an accurate result. If possible the results should be available before the seeds are packaged for planting so that poor quality seeds can be identified and eliminated.

How should viability be determined? The most accurate test of viability is the germination test and this is described above.

Why do some seeds fail to germinate in the test? Two main reasons for the failure of seeds to germinate in suitable conditions are because they are either dead or dormant. Dead seeds can be identified because they usually soften and rot during the test as a result of attack by bacteria and fungi. Seeds which remain hard or absorb water, but remain firm and in good condition during the germination test are probably dormant. Seed dormancy is common in some varieties straight after harvest (post harvest dormancy).

How can dormant seeds be stimulated to germinate? Besides drying as earlier discussed, special treatments are available to overcome seed dormancy but are not discussed in this manual.

Seed dressing

Breeders' and foundation seeds are usually very costly, hence every effort should be made to ensure their survival in the field. If the seeds to be multiplied are not already dressed, then dress them properly with the recommended seed dressing chemicals, such as Thiram. Follow the instructions on the sachet when dressing seeds.

Pre-germinating seed

Pre-germinating the seed increases rate and percentage of seedlings established. Pre-germinating, or soaking of seeds, reduces the time required for seeds to take up sufficient moisture to initiate the germination process. Seeds are normally pre-germinated when directly sown into moist seedbeds or standing water. Do not risk by sowing pre-germinated seeds in a dry seedbed as the scorching sun may kill emerging small shoot.

Procedure

1. Submerge the bag of seed in water for 24 hours or until small shoots appear at end of seed. In some cases this may take 36 hours
2. Dry the seed in bag for 24 hours
3. When drying seed make sure it is kept in the shade and air is allowed to circulate around bags. If bag temperatures exceed 42 degrees Celsius, then some seed will be damaged or sterilized
4. Plant the seed before roots exceed 5 mm in length
5. When calculating the planting rate, make allowance for expansion in seed volume

Depending on variety, the seed may increase by 10 to 30 percent of its original weight.

Planting the crop

Sow the seeds at the recommended time, most appropriately when rains have started or about to start and when good land preparation has been conducted. Rice for seed is sown in rows so as to make rouging of off types easy. In addition, weeding, fertilizer application, and other field operations also become easier. Delayed sowing can cause the crop not to mature well before the end of the rainy season. If planting is delayed, high temperatures after flowering can lower the amylose content and increase chalkiness. It is important also to remember that pest and disease attacks are more severe on late planted crops. Sow crops at the recommended spacing and soil depth as suggested (Table 1). Planting rice on dry soil is not recommended due to the erratic nature of the rainfall in Uganda this days. This could result in poor crop establishment.

Crop establishment and replanting/gap filling

Establishing the correct number of plants is essential to maximize water and nutrient use. Seeding rate and desired plant population depend on several factors: the rice ecosystem, planting technique, planting depth, seed quality and seed variety. Total number of panicles required per unit area can vary, depending on soil type and water regime. For most situations, tillers and panicles are thought of as similar although not all tillers produce panicles. A target population that results in 300-400 panicles per m^2 is desirable during the rainy season. In the dry season density increases to 500 to 600 panicles per m^2. In more fertile soils and for irrigated and dry season crops, plant populations should be increased.

Low populations may result in:

- Increased tillering, which creates more variation in panicle maturity
- Increased weed populations, and
- Reduces the yield potential of the variety

High plant populations may reduce yield and quality by:

- Competing for water and nutrients
- Mutual shading
- Lodging and
- Reduced grain size

A correct seed rate will reduce the cost of production and minimize competition for resources. Each plant develops three to seven tillers. The number of tillers will vary according to nutrient status, variety and planting rate (higher seeding rates normally give fewer tillers). Transplanted crops generally produce more tillers than direct seeded crops, and dry season crops often produce more tillers than wet season crops.

Calculate your seeding rate as follows:

What is the area to be planted? = 1 ha (100m x 100m = 10,000m^2)
How many hills/ha at 20cm x 20cm spacing? 10,000m^2/(0.2m x 0.2m) = 250,000
How many seedlings per ha at 4 seeds per hill? 250,000 x 4 = 1,000,000
Therefore total number of seeds per ha = 1,000,000 seeds
Weight of 1,000 seeds = 20 - 30g; Av = 25g
Wt of 1,000,000 seeds = 1,000,000/1,000 x 25,000g = 25kgs
% germination for rice = 50 - 90%; Av = 70%
Seed needed at 70% germination = 25kg/0.7 = 36 kgs
% seedlings that survive = 50-90%; Av. = 70%
Final seed weight needed to plant one hectare = 36kg/0.7 = 51kgs

Replanting/gap filling will delay maturity resulting in a wider range of moisture contents at harvest. Limit replanting by ensuring good land preparation and leveling. Below are different methods of planting recommended for seed production

Planting methods

Drill Seeding: Seed drill planting has many different types of furrow openers, which are designed for different soil types and crop residues. The common furrow opener is a wooden or metallic line marker. The seeds are dropped manually and thinly in a line at approximately 2 cm spacing. A smooth, level seedbed is necessary to ensure that seeds are not planted at depths greater than 3 to 5 cm. Sowing at the correct depth is when five to ten percent of the seed is visible on the surface after sowing. A good plant stand has 35 to 40 plants established per meter of drill row after emergence. The benefit of drill seeding is that fertilizer can be applied at the same time as the seed. Manual weeding is much easier in drill seeded crops than in broadcast crops.

Dibbling: In dibbling method, the number of seeds per hole depends on three factors: location, quality of seed, and price of seed. Foundation 1 seed, which is more costly, is often planted as one seed per hill while certified seeds are planted with 4 to 6 seeds in each hole. The recommended seeding is 3-4 seedlings per hill at a spacing of 30 cm x 15 cm. But ensure that the seeds are placed at correct depth, as depth affects both crop establishment and lodging potential. Broadcast crops tend to lodge more because with the seed germinating at the surface, the crown of the plant is at or above ground level. Care must be taken with seed placement as rice seeds have difficulty establishing if placed too deep in the soil.

Recommended planting methods for seed producers/ farmers

Drill planting

Dibbling

Several environmental conditions affect a seedling's capacity to emerge from the soil after seeding:

Seed/soil contact: To begin the germination process, the seed absorbs a certain amount of moisture from its surroundings. In a dry seed bed, absorption occurs after moisture distribution through the seed being in contact with moist soil or being submerged in water. For seeds to make good contact with the soil, soil clods need to be similar in size to the seed and actually make physical contact with the seed. Seed soaking or seed priming prior to planting expedites the absorption process and is often used to increase the rate of plant establishment.

Soil size in a fine seed bed

Seed placement: Rice seeds must be placed close to the soil surface. When dry seeding into heavier clay soils, place seeds within 10 to 15 cm of the surface. If seeds are placed at depths greater than this, surface sealing will restrict the number of shoots that emerge and increase the time to emergence.

Soil insects and disease: Plant establishment can be slowed down by the following soil borne insects: nematodes, crickets and wireworms. Some of these problems are alleviated by cultural controls: crop rotation, trap crops, and bare fallowing. Seed dressing protects the seed from insects that directly attack the seed. For stem and root protection, it is necessary to use the appropriate pesticide through surface application or soil fumigation.

Gap filling and thinning

Often, after planting, some stands may be missing for several reasons such as bird removal, non-germination or too deep planting, or omission during planting. To ensure a good plant population, fill the gaps (missing stands) by sowing at one week after planting. Do not fill the gaps late because this can cause non-uniformity in maturity time and thus contaminate the seeds. Thin or remove any extra plants/stand above the number recommended at 2 weeks after sowing to reduce plant competition for light, nutrients and water.

Steps in Seed Paddy Production

Nucleus seed
The first lot of seed produced by the breeder. A portion of this will be kept in long term storage and the balance is used to produce Breeder's seed.

Breeder's seed
Seed produced by the breeder, planted in plant to row basis, single plant per hill. Usually the progenies with off-types are eliminated. Breeder retains a sample of single plant selections prior to harvest of the progenies for the next cycle of breeder's seed production The harvest will be used to produce Foundation seed.

Foundation seed
Produced usually under supervision of breeder. Normally a transplanted crop with very high standards of management. Weeds and off-types are regularly eliminated. The harvest is used to produce Registered seed.

Registered seed
Produced following the procedure above but, without mandatory supervision of the breeder. Usually by organizations with experience in seed production. Harvest is used to produce Certified seed.

Certified seed
Produced usually by seed producers, who are seed farmers or farmer organizations in most instances. Genetic purity, free of weed contamination are important in seed production. Harvest goes as certified seed paddy for cultivation.

Planting Procedure

i). Nucleus seed (Produced by a Breeder)

- Spacing:
  - among rows: 60 cm
  - within rows: 15 cm

- No. plants/hill: One
- Weed regularly
- Rogue off types
- Select 100 to 150 individual plants for breeder seed progenies
- Harvest the bulk for cold storage

Nucleus Seed Plot

ii). Breeders seed (Produced by a Breeder)

- Establish 3 row plots separately from each plant:
  - Plot length: 3 m
  - Between plots: 60 cm
  - spacing among rows: 30 cm
  - within rows: 15 cm
  - No. plants/hill: one

- Weed regularly
- Rogue off-types, volunteer plants, admixtures
- Discard heterogeneous/segregating progenies
- Select 150 individual plants from middle row of uniform progenies
- Harvest the bulk as Breeder's seed

Breeder's Seed Production Plot

Bund for collecting run-off water

Breeder's Seed Production Plot

iii). Foundation seed (Produced by a Breeder and registered seed producer)

- Plant in rows:
    - Spacing among rows: 20-30 cm
    - within rows: 15/20 cm
    - No. of plants: 3-4 plants/hill

- Weed regularly
- Rogue off-types, admixtures, volunteer plants
- Use the harvest for Registered seed production

Use the same plot of land regularly

iv). Registered seed (Produced by seed producer without mandatory supervision of a breeder)

- Plant in rows:
    - Spacing among rows: 20 cm
    - within rows: 15 cm
    - No. of plants: 3-4 plants/hill

- Weed regularly
- Rogue off-types, admixtures, volunteer plants
- Use the harvest for Certified seed production

Use the same plot of land regularly

v). Certified seed (Produced by seed producers)

- Follow the procedure for registered seed
- No mandatory supervision/inspection by breeder
- Inspection by government seed inspectors

Weeding

Direct seeding (especially dry direct seeding) results in greater weed pressure. The traditional system of transplanting gave the crop a competitive advantage over the weeds. In addition, the crops are usually transplanted into standing water – which was an additional factor in reducing weed pressures. The weed pressure in upland rice is now overwhelming and requires more man hours than in transplanted fields. Weed control is important for both the direct effects that weeds have on yield and production costs as well as the indirect effects they can have on seed quality. Weeds decrease yields by direct competition for sunlight, nutrients, and water and/or by allelopathy. Allelopathy is the production of chemicals by the plant that inhibit the growth of surrounding plants. For each 1kg of weeds, the loss in yield is approximately 0.75 kg. Secondly, weeds increase production costs e.g., higher labor or input costs, and thirdly, weeds reduce seed quality and price, for example, weed seeds in seed can cause the seed to be disqualified. Weed seeds in grain can also cause uneven moisture gradients in the grain causing loses in grain quality due to the formation of molds and/or due to cracking losses during milling. Therefore, timely control of weeds is critical for high seed yield and quality. Start weed control at 2 weeks after sowing or even earlier, depending on the level of weed infestation, with a second weeding at 4–5 weeks, and a third weeding at 7–8 weeks, depending on the duration to maturity of the rice crop and the level of weed infestation. Alternatively, apply pre-planting herbicides such as glyphosate and sow 2 weeks later, or spray with gramoxone, which is another pre-planting herbicide 1–2 days after sowing the crop seeds. In Uganda, post emergency herbicides like Propanil + Thiobencarb combinations are the best for rice management. Satunil herbicide is also preferred in some places. Remember, the use of herbicides requires some knowledge of the right product for a particular crop, the right time to apply it using the correct sprayer calibration. Seek advice from your extension agent on appropriate herbicide types and rates if you are not conversant with their use. Ensure that the farm is weed-free at all times to get good quality seeds that are well filled and will perform vigorously from planting to maturity. It is recommended to avoid weeding operations when the rice crop has flowered, as it causes low yield due to flower abortion.

Fertilizer application

Ensure timely and uniform nutrition across the field. Uneven crop nutrition can lead to variation in tillering and grain maturity across a field resulting in a range of grain moisture content at harvest. Nutrition can also affect head rice and amylose content. Delayed nutrition may lead to delayed growth and crop maturity, which increases the probability of the crop being affected by adverse weather during harvesting season (eg. heavy rains, etc.). The time of fertilizer application depends on the type of fertilizer and on the crop growth stage. In general, apply 3-4 50 kg bags of Diammonium Phosphate (DAP) or Single Super Phosphate (SSP) at land preparation or at planting depending on the fertility of the soil. Apply nitrogen in split doses, if in the form of compound (NPK) fertilizer, at one week after sowing. Apply the second dose of nitrogen at 4–5 weeks after sowing in the form of Urea (46%N).

DAP fertilizer

Urea fertilizer

Calculating fertilizer rates

Amount of Fertilizer $= \dfrac{\text{Amount of nutrients to achieve target yield}}{\text{Recovery efficiency of nutrient}}$

Generally, 17 kgN, 3 kgP and 17 kgK are needed to produce a ton of grain yield

Example:
Calculate the amount of N, P and K required to produce 7 tons of rice grain yield. Assuming the indigenous supply is 15 kgP and 85 kgK, what is the rate added? (the apparent recovery rate for P and K are 20% and 40% , respectively)

P rate $= \dfrac{(3 \times 7)-15}{0.2} \times 2.3 \text{ (to convert into } P_2O_5) = 70\text{kg } P_2O_5/\text{ha}$

Computing amount of fertilizer material

Amount of fert $= \dfrac{\text{Fert rate(kg/ha)} \times \text{area} \times 100}{\text{\% nutrient in the fert material}} \times \dfrac{1 \text{ ha}}{10{,}000 \text{ m}^2}$

Question

148 kg N/ha, 70 kg P_2O_5/ha and 102 kg K_2O/ha are needed to fertilize 5000 m^2 and the fertilizer material includes urea, complete fertilizer (14-14-14) and muriate of potash

Amount of complete fert needed (14-14-14) for satisfying 70kgP

$$\frac{70 \times 5000 \times 100}{14} \times 1/10000 = 250 \text{ kg of 14-14-14}$$

250kg of 14-14-14 also satisfies 70 kgN and 70 kgK

The remaining fert rates to be satisfied are

148-70 = 78 kgN and 102-70 = 32 kgK

Amount of urea $= \dfrac{78 \times 5{,}000 \times 100}{46} \times 1/10{,}000 = ?$

Muriate of potash $= \dfrac{32 \times 5{,}000 \times 100}{60} \times 1/10{,}000 = ?$

The plant needs sufficient N during establishment, tillering and just prior to and during panicle initiation (sink size). Most of the plants N should be applied prior to or around panicle initiation. Sufficient N during grain filling to ensure production of photosynthate to fill the grains (generally 70% from remobilization within plant). The rule of thumb is that; every day the crop is yellow, yield is being lost, so apply N to observed yellow patches in the field. K requirements can be reduced to 3-5 kg/ha per ton of grain yield if the straw is evenly distributed in the field. To reduce the risk of lodging and pests, do not apply excessive amounts of N fertilizer between panicle initiation and flowering stage, particularly in the wet season.

It is important that the straws are incorporated as an organic matter. This is because much of the nutrients are lost in the straw. For an average yield of 5 tonnes/ha, about 100 Kg of Nitrogen is lost. This requires up to 500 Kg of straw to replenish this loss. Straw should be incorporated in the field at least 30 days before actual planting.

Fertilizer rates and regimes

For soils sufficient in K use 55-23-0 NPK kg/ha in the form of DAP and Urea as discribed in the table below.

Fertilizer	15 - 20 DAG*	55 - 65 DAG*
DAP (18-46-0)	50 kg / ha (20 kg / acre)	0
Urea (46-0-0)	50 kg / ha (20 kg / acre)	50 kg / ha (20 kg / acre)

*Days after Germination (allowing 5 days between sowing and emergence).

But
For soils that are low in K, the use of 62:26:26 NPK kg/ha in a form of 150 kg/ha of NPK 17:17:17 and 15 to 20 DAG with additional top dressing of 30 kg/ha Urea at 15 to 20 DAG 50 kg/ha at 55 to 65 DAG are recommended.

Insect Pests of Rice

Stalked-eyed flies *(Diopsis thoracica)*

The larvae bore and feed on plant tissue inside the rice stem causing dead heart. It belongs to a group of stem borers which are generally considered the most serious pests of rice worldwide

- Occur and infest plants from seedling stage to maturity
- The initial boring and feeding by larvae in the leaf sheath cause broad, longitudinal, whitish, discolored areas at feeding sites
- About a week after hatching, the larvae from the leaf sheaths bore into the stem and, staying in the pith, feed on the inner surface of the walls. Such feeding frequently severs the apical parts of the plant from the base
- When this occurs during the vegetative phase of the plant, the central leaf whorl does not unfold, but turns brownish and dries off, although the lower leaves remain green and healthy
- This condition is known as deadheart

Control methods

Cultural control

- Some methods are effective only if carried out through communitywide

cooperation; others are effective on a single field
- Communitywide practices act to prevent colonization of rice crop through time and space
- Single field include using optimal rates of N fertilizer in split applications
- Applying slag increases the silica content of the crop, making it more resistant

Chemical control

- Stem borers are difficult to control with insecticides. After hatching, the larvae are exposed only for a few hours before they penetrate a tiller or enter the plant. Successful control involves repeated foliar applications
- For chemical control seek advice from your agricultural officer

Resistant varieties

- Resistant varieties do exist, but it is not known which varieties are resistant in Uganda

African Rice Gall Midge *(Oreolia oryzivora)*

The African rice gall midge is an insect pest of lowland rice. The larvae attack the growing point of the apical bud at a node and cause the leaf sheath tissues to form a tube-like structure called a ‘silver shoot gall’ or ‘onion shoot’.

Control methods

- Rice fields planted early are less damaged than those planted late
- Some varieties are resistant in Uganda

Rice Leaf folder *(Lepidoptera, Pyralidae)*

The larva scrapes the leaves and folds the leaf together and scrapes inside.

Control methods

Cultural

- It is advised not to use too much fertilizer - highly fertilized plots attract females
- Surrounding grass habitats should be maintained because these serve as temporary reservoirs of natural enemies like crickets, which are egg predators of leaffolders

Biocontrol

- There are small wasps and crickets that attack the eggs
- The larval and pupal stages are parasitized by many species of wasps
- Damselflies, ants, beetles, wasps, mermithids, granulosis virus, and nucleopolyhedrosis virus prefer the larval stages
- Spiders and mermithids attack the adults

Resistant varieties

- Some varieties are resistant

Chemical control

- Use of Chemicals during the early crop stages is not advisable
- A general rule-of-thumb is “spraying insecticides for leaffolder control in the first 40 days after sowing (or 30 days after transplanting) is not needed
- The rice crop can compensate from the damage when water and fertilizer are well

managed

- Pyrethroids and other broad-spectrum insecticides can kill the larvae but can put the crop at risk because of the development of secondary pests, such as the brown planthopper
- If infestations of the flag leaves are extremely high (>50%) during maximum tillering and maturity stage, insecticide sprays may be useful

Stem borers *(Pyralidae)*

The larvae bore through the stem and eat up the plant tissue resulting in a condition called dead heart and / or white head.

Larva

Adult

Damage (white head)

Damage and Symptoms

- **Dead hearts** - Young tillers which have dried up and died after borers have cut off the growing part from inside
- **White heads** - Empty, whitish panicles resulting from stem borer attach after panicle initiation had already occurred
- **Holes in the stems** - Indicate where the borer entered the stem
- Presence of adult insects

Control methods

Cultural control

Crop cultural practices have a profound bearing on the stem borer population. However some methods are effective only if carried out through communitywide cooperation; others are effective on a single field. Communitywide practices act to prevent colonization and have the greatest potential to minimize infestation. In general cultural methods include:

- Isolation of the rice crop through time and space
- Using optimal rates of N fertilizer in split applications
- The height at which a crop is harvested is an important factor in determining the percentage of larvae that are left in the stubble. At harvest, *Chilo suppressalis* larvae are usually about 10 to 15 cm aboveground, thus harvesting at ground level can remove a majority of the larvae of all species
- Deep ploughing the stubble is the most effective because the stubble is the major source of the overwintering stem borer population
- Crop rotation to include some shortduration nongraminaceous crops should significantly reduce the borer population
- Early planting may result in a reduced impact from stem borers

Biological control

- Predators, parasites, and entomopathogens help in controlling stem borers, for example:
  - ♦ The egg parasitoids *Telenomus, Tetrastichus,* and *Trichogramma*
  - ♦ The long horned grasshopper, *Conocephalus longipennis* (Haan) preys voraciously on eggs of the yellow stem borer
  - ♦ Other predators such as the crickets

Varietal resistance

- Rice varieties vary in their susceptibility to stem borers

Chemical control

- Stem borers are difficult to control with insecticides

Stink bug and Rice bug *(Asparia armigera)*

The adult rice stink bug is 8 to 12 mm (5/16 to 1/2 inch) long, rice straw color, pale reddish antennae, slender body, and sharply pointed humeral (shoulder) spines that are directed forward and slightly outward. The bugs stay on the panicle and suck the milky juice in young panicles causing staining of the grains hence lowering grain quality.

Stink bug

Rice bug

Damaged rice

Damage and Symptoms

- Adults and nymphs have piercing-sucking mouthparts
- Entry of the stylets (mouthparts for feeding) is facilitated by a salivary secretion which hardens on contact with air and remains attached to the rice grain. It is called a feeding sheath
- Attack during the early stages stops any further development of the kernel (a yield loss)
- Attack during kernel filling stages removes a portion or all of the kernel contents (also a yield loss); but pathogens are mediated (vectored) into the kernel by the rice stinkbug

Control methods

- Rice fields should be scouted weekly or twice weekly beginning at 75% panicle emergence and continued for 4 weeks
- Avoid scouting from mid-day through late afternoon
- Make 10 consecutive 1800 sweeps to the front and sides while walking forward

and swinging the net from side to side
- Hold the net so that the lower half of the net is drawn through the foliage and panicles
- Calculate the average number of rice stink bugs per 10 sweeps. Apply insecticide if infestation is 5 or more rice stink bugs per 10 sweeps during the first two weeks after heading

Rice mealybugs

Mealy bugs are plant-sucking, relatively immobile insects belonging to the family Pseudococcidae. They secrete white filaments of wax to cover themselves. They are widely distributed throughout the world and are considered economically important pests of a variety of host plants.

Damage

- Nymphs and adult females infesting the leaf sheath and damage the plant by sucking sap from the rice stem, that results in smaller leaves, yellowing, abnormal tillering, and stunted plants
- Under heavy infestation, either no panicles are formed or they do not fully exsert from the boot; the plants may even dry off
- The damage is in patches since the young nymphs have rather limited migrating ability
- Mealybug numbers vary greatly between hills
- This causes the field to have several spots of depressed growth

Control methods

Cultural control

- Timing of planting dates to escape peak infestation, and removal and destruction of infested plants at the first sign of mealybug damage.

Biological control

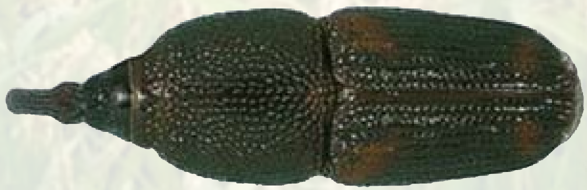
- Ladybird beetles such as *Coccinella repanda* (Thunberg), *Menochilu sexmaculatus* (Fabricius), and *Harmonia octomaculata* (Fabricius) are the main natural enemies of the mealybug
- Hymenopterous parasites

Chemical control

- The waxy secretion covering the mealybugs and their habit of living behind leaf sheaths protect them from insecticide
- Foliar sprays are effective, however, if the nozzle is directed to the bases of plants

Rice weevil *(storage insect)*

The adults are around 2 mm long with a long snout. The body color appears to be brown/black, but on close examination, four orange/red spots are arranged in a cross on the wing covers. It is easily confused with the similar looking maize weevil, but they have several distinguishing features.



Control methods

- Grain spillage on the ground and the floor can accumulate in cracks and the rails of storage racks and create breeding sources for the weevils
- When rice or granary weevils are present in grain for a period of time, other stored product beetles and moths may infest the grain

- When weevils are most often found infesting larger quantities of grain in storage bins, silos, grain elevators and bags of stored grain warehouses, fumigation is generally the only treatment option
- If smaller packages or quantities of infested grain are involved, the grain can be discarded and the cracks in the area where the infested grain was stored treated with a residual insecticide
- Treating rice seed/grain with insecticides (e.g. Actellic) before storage is also a common practice

Termites *(e.g., Macrotermes gilvus (Hagen), Heterotermes philippinensis (Light))*

- Generally known as white ants because of their overall similarity to ants in body shape, wings, and the caste system of workers, soldiers, king, and queen
- Termites are a problem in upland rice, but can also occur in light textured soils in rainfed wetland areas
- Infestations are severe on light textured soils with low moisture content

Control methods

Cultural control

- Placing crop residues in the field at planting time can divert the pest from the growing crop

Chemical control

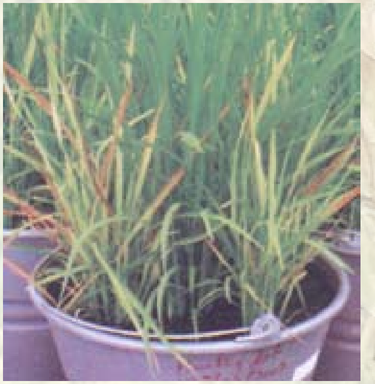
- Chemical control includes treating seeds with insecticides at planting or applying granular insecticide in the seed furrows or hills
- The decision to use insecticides should be based on the history of termite damage in a particular field

Diseases of Rice

Rice Yellow Mottle Virus *(RY\1V)*

RYMV is known only in Africa and one of the most damaging diseases of rice in Africa RYMV is now a severe problem in eastern and northern Uganda.





Symptoms
- Stunting of rice plants if infected at early stage
- Reduced tiller number
- Yellowing and mottling of leaves
- Infected plants are easily attacked by other diseases (such as brown spot)

Transmission of RYMV
- RYMV is transmitted by a vector and also mechanically

Control of RYMV
- There are no practical ways (no chemicals) of curing a plant after it becomes infected
- Planting resistant varieties is the cheapest and most effective way of controlling RYMV
- Tolerant varieties: NERICA 4, 6, NARIC 1, 2

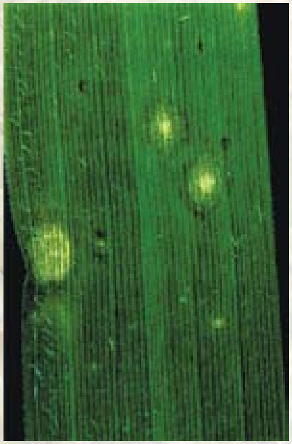
Eliminating sources of Virus

- Rogue (remove) infected rice plants from the rice field. Roguing is successful when only a low percentage of plants are infected
- Prevent ratoon growth, which is a main source of RYMV
- Direct seeding (Not transplanting) can reduce the occurrence of RYMV

Rice Blast *(Magnaporthe grisea)*

Rice blast is one of the most destructive diseases of rice. It has a potential to cause up to 50% yield loss when conditions are favourable, but 100% yield loss has been observed in very susceptible varieties.

Blast can infect rice from seedling stage through to maturity.


Initial symptoms


Lesions enlarge

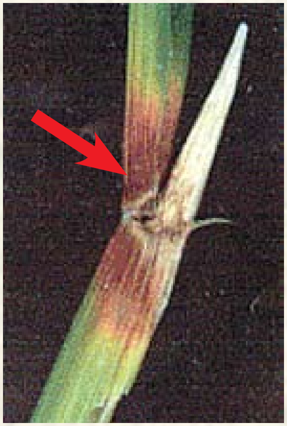

Mature lesions


Multiple infections

Symptoms

Symptoms can appear on leaves, leaf collar, stems, nodes, panicles and grain. The disease can also be called leaf blast, collar rot, node blast, panicle blast or rotten neck blast, depending on the part of the plant on which the symptoms develop.

Leaf blast



Collar rot

Node blast

Neck blast

Symptoms are as follows:

Leaf blast

- Begin as small white to gray-green lesions or spots with dark borders
- Lesions enlarge quickly under moist warm conditions to either oval spots with grey or white centres and narrow brown or reddish brown borders
- Lesions usually become diamond shaped or linear with pointed ends
- As lesions mature their centres often appear cottony on the surface and dark bluish due to the production of conidia (spores)

Collar rot

- Collar rot phase occurs due to infection at the junction of the leaf blade and the sheath resulting in a characteristic brown to dark brown lesion
- Severe collar rot infection often kills the entire leaf

Node blast

- Lesions on stem nodes cause the rice tissue to turn blackish and to shrivel as the plant approaches maturity
- Infected areas may become dark purple to blue gray due to production of conidia
- Node blast may cause the plant to lodge or break off at the infected nodes

Neck rot, rotten neck and panicle blast

- Neck rot phase is caused by infection on the neck node
- Symptoms appear at the base of the panicle starting at the node
- The infected tissue turns dark brown to black and shrivels
- Panicles usually turn straw coloured

Control methods

An integrated management programme should be implemented to avoid overuse of a single control method. Below are some control measures which could be used in an integrated approach or in isolation:

- Plant resistant rice varieties. Most of the NERICA rice varieties are generally tolerant to Rice blast
- Plant disease free rice seed such as certified seed
- Excessive use of nitrogen fertilization as well as drought stress increase rice susceptibility and should therefore be avoided
- Eliminate crop residue to reduce the occurrence of overwintering which becomes a source of inoculums for subsequent seasons
- Chemical control should be used only when it is necessary – talk to your Agriculture Officer if you need to use fungicides

Sheath Blight *(Thanatephorus cucumeris)*

- Sheath blight causes spots on the leaf sheath
- High temperature and humidity increase the severity

Disease cycle

Sclerotia develop on lesions and drop to the soil.

- The fungus survives as sclerotia in the soil
- The sclerotia float on the water surface during land preparation
- The sclerotia germinate and fungus penetrates the plant
- The fungus grows on the plant

Damage caused by sheath blight

- Many of the leaves are killed during severe infections and yields may be reduced by 20-25%

Control

- No variety has a high level of resistance to the disease. Do not apply too much nitrogen
- There are effective fungicides controlling the disease, but are economically not recommendable

Brown spot *(Cochliobolus miyabeanus)*

The disease is common in soils that are poorly drained or deficient in nutrients.

Symptoms

- The symptoms are brown spots on the leaf and grain

Disease transmission
- The disease is transmitted by the infected seeds

Damage of brown spot
- It lowers grain quality and weight

Control
- The most effective way of controlling brown spot is to grow plants in good soil and provide adequate fertilizer
- Planting a resistant variety is the most practical way of controlling
- Treating the seeds with fungicide or hot water help in controlling the disease

Leaf scald *(Metasphaeria albescens)*

Symptoms
- The symptoms are necrotic lesions starting from leaf tip

Disease cycle
- The fungus survive on the rice straw
- The fungus penetrate lower leaves
- Flooding of rice induce severe occurrence of this disease

Damage by leaf scald
- It lowers the filled grain and grain quality

Control
- Avoid excess nitrogen fertilizer

Sheath rot *(Sarocladium oryzae)*

Symptoms
- Spots develop on the uppermost leaf sheaths enclosing panicles
- The young panicles remain in the leaf sheath or emerge partially
- Grains remain unfilled or are discoloured

Disease cycle
- Disease is usually found in plants injured by insect or diseases, particularly stem borer and virus (RYMV)
- Hot humid weather favors sheath rot development

Damage by sheath rot
- Little is known about crop losses caused by sheath rot

Control
- Little is known about control of this disease

Grain rot *(Burkholderia glumae)*

Symptoms
Usually, after heading, spikelets loose green colour and become whitish then finally turn to brown.

Disease cycle
- Seed transmitted disease
- Hot humid weather favours grain rot development
- This disease is also transmitted by wind and rain from infected panicles to near by panicles


Damage of grain rot
- It lowers grain quality and weight

Control
- There is no resistant variety for this disease
- There are several fungicides which effectively control grain rot but for economic reason, these are not used in the tropics

False smut *(Claviceps virens)*

The occurrence of the disease is believed to indicate a good yield because weather favourable to the development of false smut also favours good crop production.

Symptoms
- The fungus changes single grain of the panicle into velvety balls, which may grow to a diameter of 1cm
- Usually, only a few grains on the panicle are infected and the rest remain normal

Damage of false smut
- Usually, damage of this disease is minimal

Control
- Usually, no control measures are necessary


Rice threshing

Post harvest Handling

During pre-harvest operations, efficient technology and input management, as well as timeliness of activities, are important, and this applies also to postharvest operations for good yield and quality in order to obtain good prices for rice seeds. Correct timing at harvest is essential to avoid losses incurred by harvesting too soon or too late. Immature grains harvested too early result in a high percentage of cracked seeds, while if harvesting is delayed; the crop is exposed to insects, rodents and birds, in addition to the risks of lodging and shattering. The optimum harvest time should be chosen depending on the variety planted. For example NERICA 4 should be harvested 30-35 days after flowering.

Other indicators for optimum harvesting time for rice seed are as follows:

- When the rice has reached the exact date of maturity or numbers of days after heading (usually 28-35 days)
- When 80 percent of the grains have changed from green to straw colour
- When at least 20% of the grains at the base have a hard dough stage
- When the grain moisture content is between 21 and 24 percent
- When the hand-dehulled grain, as indicated by daily tests near the projected harvested date, is clear and hard

Harvesting methods commonly used by farmers in Uganda

There are a variety of different methods for rice harvesting, with traditional manual methods prevailing in the country:

a. Panicle reaping

This is accomplished by using a hand-held cutting knife. The method is used in areas where traditional varieties are resistant to shattering. Resistance to shattering is particularly important during handling and when transporting the bundles of panicles from field to house. The labour time required for this method is 240 labour-hours/ha (done mostly by women and older children), which is four times that required with the hand-sickle method. It remains popular because of the social custom of chatting while working. In addition, it generates income among the landless rural population.

b. Long stalk cutting by sickle

This is a widely used manual method presenting different styles in the design. It requires between 80 and 180 labour-hours/ha. The stalk is cut about 10 to 15 cm above the ground or with a stalk length of about 60 to 70 cm for easy bundling and threshing. Reaping efficiency depends on various cultural practices, plant density and variety, degree of lodging, soil conditions and the skill of the harvester. Lodged paddy and saturated soils may considerably reduce the cutting rate.

Threshing

During threshing the rice kernel is detached from the panicle, an operation which can be carried out either by “rubbing”, “impact” or “stripping”. Rubbing may be done with trampling by humans, animals, trucks or tractor; however, the grain becomes damaged. Mechanical threshers adopt mainly the impact principle, but there is also a built-in stripping action.

(i) Pedal operated paddy threshers:

Paddy crop is easy to thresh by beating but the losses are quite high. Pedal operated paddy threshers reduce drudgery. These types of threshers consist of rotating drum having pegs on its periphery and are operated by pedal. The work capacity of such threshers is 40-50 kg per hour.

Mr. Tsuboi from JICA - Namulonge demonstrates how to use a pedal thresher

(ii) **Power operated paddy threshers:**

The power operated rasp bar type, wire loop type, semi axial and axial flow threshers are also available. These threshers are operated by 5-10 hp electric motor or diesel engine and tractor. The work capacity of these threshers varies from 200-1300 kg per hour.

Farmers using a power operated thresher

Losses may occur during threshing for various reasons:

- In manual threshing by beating, some grains remain in the bundle panicles and a repeat threshing is required
- Grain is scattered when the bundles are lifted just before threshing
- Grain can stick in the mud floor
- Birds and domestic fowls feed on the grain

Drying

Rice seed as a living biological material, absorbs and gives off moisture depending on: rice seed moisture content, relative humidity of the air and temperature of the surrounding atmosphere. The respiration of the paddy is manifested in various ways: decrease in weight of dry matter; utilization of oxygen; evolution of carbon dioxide; and the release of energy in the form of heat. However, respiration is negligible when the moisture content is between 12 and 14 percent.

By and large, paddy is harvested with moisture content of 21% to 26% (higher in the rainy season and lower in the dry season). Seeds have a high respiration rate and are susceptible to attacks by micro-organisms, insects and other pests. The heat released during the respiration process is retained in the grain and in the bulk due to the insulating effect of the rice husk, resulting in losses in terms of both quantity and quality. Therefore, harvested grain with high moisture content must be dried within 24 hours: to 14% for safe storage, or at most 18% for temporary storage of 2 weeks when it is not possible to dry any faster. Delayed drying may result in non-enzymatic browning (stack-burning), microbial growth and mycotoxin production. Small rural farmers can use tarpaulins for paddy sun-drying.

The main constraint of sun-drying is the dependence on good weather conditions, which can become a serious problem, particularly in tropical rainy countries. Losses due to bad drying practices range from 1 to 5% and it is mainly the quality which is affected. Good drying is crucial for minimizing post-harvest losses, since it directly affects safe storage, transportation, distribution and seed quality.

A temperature of 43°C is recommended for drying paddy for seeds and this can be achieved with shade drying. Higher temperatures can lead to physicochemical disorders in the seed. The temperature for drying paddy should not be higher than 54.4°C for food grain and 43°C for seed. Low temperatures help preserve the rice aroma principle 2-acetyl-1-pyrroline.

The main causes of losses during drying are:

- Grains shattering from stalks or spilling out from bags during transport
- Birds and domestic fowls
- Spill-out outside the drying area
- Over-drying, especially during sun-drying
- Delayed drying or no grain aeration, resulting in stack-burning

Paddy cleaning

This is an important operation and highly recommended not only on a large and medium commercial scale, but also on a small scale. It consists of the separation of undesirable material, such as weed seeds, straw, chaff, panicle stems, empty grains and damaged grains, sand, rocks, stone, dust, plastic and even metal and glass particles. The degree of cleanness of the paddy reflects to some extent the care applied during harvesting, threshing and handling.

In Uganda, farmers clean the paddy straight after manual threshing. First, they use hand-raking and sifting to remove straw, chaff and other large and dense materials, then winnowing, i.e. making the grain/seed fall down to be collected on a surface such as tarpaulin or a nylon sheet on a windy day. The method depends on air natural conditions and is very slow.

a. Winnowing fans:

The hand operated and power operated winnowing fans are commercially available. The paddy threshed by manual beating or by pedal operated paddy thresher is cleaned by using these fans. These winnowing fans consist of frame either made up of wood, angle iron, welded steel or combination of the two along with driving mechanisms namely, sprocket and chain, belt and pulleys and single or double reduction gears.

Rice winnowing

Storage

The storage structure must protect the paddy/seed from: extreme heat or cold; moisture, which causes microbial and fungal growth; and insect pests and rodents which consume or damage the rice. At farm household level, storage is essential for food security or as a commodity bank for conversion into cash when required and ofcourse for planting the seed later. Unfortunately, small-scale or marginal farmers often lack the resources to store large amounts of seed and do not have a large storage structure; they therefore are obliged to sell their paddy/seed to seed companies or to traders or buyers immediately after harvest. They carry out no further processing (drying, cleaning and grading) because of the immediate need for cash, and there is a lack of incentive to dry.

The main causes of losses during storage are:

- Attack by insects, rodents and birds as a result of inadequate protection
- Long-term storage with 14% or higher moisture content, for more than 2 weeks' storage with 18% moisture
- Theft and pilferage in the storage house

The seed retained for storage is sun-dried several times and cleaned before loading into the storage container. The seed producer determines the dryness required for storage on the basis of experience.

Dryness is measured by pressing a bunch of grains into the hand orbiting several grains: a fully dried grain is hard. Paddy is usually stored with a moisture content of 14% or less. Paddy is normally stored in a 1-tonne-capacity container for 6 to 12 months.

Equilibrium moisture content of paddy (%)*

Humidity	Temperature (ºC)			
RH %	**22**	**28**	**36**	**44**
50	11.2	10.7	10.2	9.9
60	12.3	11.8	11.4	11.0
70	13.5	13.1	12.6	12.3
81	15.3	14.9	14.4	14.1

* IRRI Training Module

Guidelines for seed storage moisture content

Moisture Content

- Grain (storage) < 14%
- Seed (8 – 12 months) 10 – 12%
- Seed (more than 1 year) < 9%
- Seed (germplasm conservation) 6%

Storage temperature – germplasm conservation

- Medium term (20 – 40 Years) 2 ºC
- Long term (50 - >100 Years) -20 ºC

Drying temperature at high moisture levels (>9%) should not exceed 45 ºC. Maximum drying temperature is around 60 ºC.

Traditional storage structures

Management aspects in seed production

Field inspection and rouging

Regular field inspections are critical to identify off-types and to remove them before they contaminate the seed farm. Field inspections should be conducted at vegetative, flowering, pre-harvest, and harvest stages. The volunteer paddy plants emerging from the shattered grains of the previous crop have to be removed as and when they are noticed in the field. By regular field visits, follow the plant growth and development while attempting to make visual comparison of varietal characteristics. Look at, collectively, the characteristics of the plant population and that of the individual plants to be familiar with the cultivars so that you can differentiate one population from the other. Walk in the field in a clockwise direction and identify and count off-types and diseased plants in a strip 1m x 25m. Pull out diseased plants and off-types observed in the field. Finish with one strip at a time before going to the next strip. If the seed farm is 2–6ha, make counts in 6 strips of 1m x 25m; if more than 6–10ha, make 9 counts; more than 10–12ha, make 20 counts, more than 12–16ha, make 28 counts, and above 16ha make 32 counts in the 1m x 25m strips. Remove all plants that are abnormal from the field. You may need to employ laborers to assist with removal of off-types or diseased plants if the level of impurities is high. Removing the impurities (off-types) before the visit of external field inspection officers from National Seeds Certification Service will save your farm from being rejected. The following characteristics would be helpful to differentiate one variety from the other and also to identify the off types in a population of a genetically pure variety.

- Plant type
- Growth duration
- Vigor
- Height
- Tillering habit (compact / spreading)
- Leaf characteristics (narrow /broad, erect / droopy, long / short)

- Pigmentation
- Panicle type (open / lax)
- Spikelet size and shape
- Stigma and apiculous pigmentation
- Presence of awn
- Hull color
- Grain size and shape
- Pericarp color (red / white)

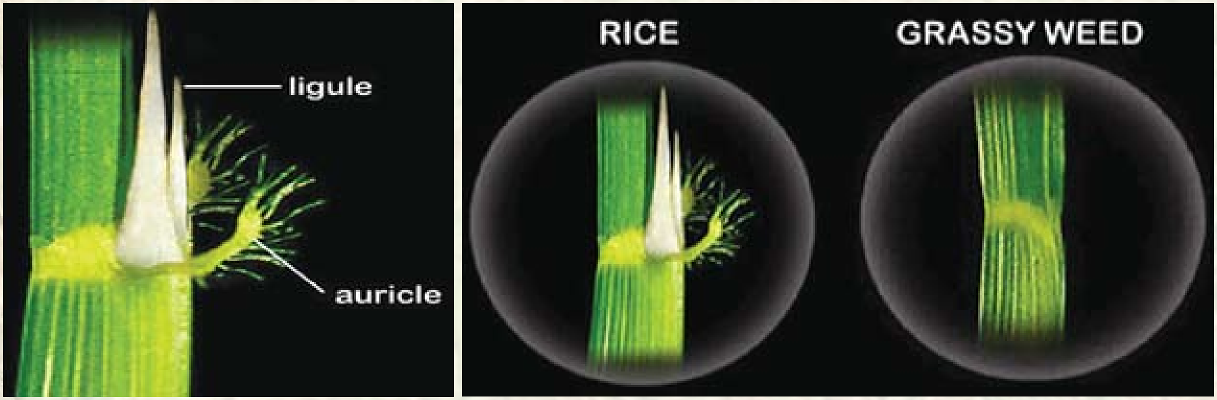
Quality control

Seed certification and seed testing together form the quality control component of a seed programme. These operations are conducted by both the seed producer and the government seed certification agency. You can register your seed business with the National Seed Certification Service and invite the officers to inspect the farm at least twice during the growing season. The officers will also conduct field inspection to ascertain whether the isolation of the field is appropriate, check for off-types and diseased plants, and make yield estimates for the farm. The report of the officers will serve as the basis for accepting or rejecting the field as a seed farm and issuing a field certificate that will provide the legal basis for the produce to be sold as true-to-type seeds. Allow the seed officers to take samples of the produce for further identification and analysis in their laboratories. Adopt all recommendations made by the field certification officers during the inspection. Seed producers pay a token fee for the field certification and the certificate issued is valid for one year. It is important that you are conversant with the Seed Act if you intend to engage in seed business in Uganda.

Off-types in rice

- Any outstanding different rice plant in seed production plot could be an off-type
- Examine the plant population carefully. Be familiar with the general features of the cultivar. With gain in experience, the off-types can be located
- The following characteristics would be helpful to identify offtypes

- Plant vigor, height, tillering habit, leaf characteristics, pigmentation
- Panicle type, spikelet size and shape, stigma pigmentation, apiculous color, presence of awn
- Hull color, grain size and shape, pericarp color



Grass weeds and rice

Features of good quality seed

- Fully mature
- Well filled
- Uniform in size
- Healthy
- Pure
  - Breed true to type – genetically pure
  - Free of admixtures, off-types
  - Free of contaminants, weed seeds, inert matter
- Viability
- Seedling vigor

Steps in seed processing

- Harvesting
  - Stage of maturity (30 – 35 days after heading)
  - Moisture content (21 -25%)

- Threshing
  - Moisture content (21- 25%)

- Drying
  - Moisture content (14%)

- Cleaning /Winnowing
- Grading
- Storage
  - Moisture content (< 14%)

Guide to seed quality standard

Item	Breeder	Foundation	Registered	Certified
Purity (% by weight)	98	98	98	97
Inert matter (% by weight)	2	2	2	3
Weed seed (500g seed)	0	1	2	5
Other varieties (500g seed)	0	2	6	12
Germination (%)	80	80	80	80
Moisture (%)	14	14	14	14

The standards above can be considered minimum standards.

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Notes

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